Chapter 14
Harnessing Hybrid Solar Panels for Sustainable Urban Energy Solutions Into Blue-Green Infrastructure

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ABSTRACT

Urban areas face increasing challenges in meeting energy demands while promoting environmental sustainability. This chapter explores the potential of hybrid solar panels as a key component in sustainable urban energy solutions, particularly within blue-green infrastructure. Hybrid solar panels, which combine photovoltaic cells and piezoelectric sensors, offer a dual approach to capturing renewable energy, enhancing their utility in urban settings. This integration emphasises their compatibility with blue-green infrastructure elements such as green roofs, water management systems, and public green spaces. By incorporating hybrid solar panels into blue-green infrastructure, cities can develop resilient, energy-efficient environments that promote sustainability and enhance the quality of urban life. Furthermore, the chapter provides valuable insights and practical recommendations for urban planners, policymakers, and stakeholders seeking to leverage renewable energy to develop sustainable urban ecosystems.

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INTRODUCTION

The rapid urbanisation of the 21st century has brought about significant challenges in energy consumption, environmental sustainability, and climate resilience. Cities, which house over half of the global population, are major energy consumers and significant contributors to greenhouse gas emissions. As the world moves towards more sustainable development goals, there is an urgent need to explore and implement innovative energy solutions to meet urban energy demands while minimising environmental impacts.

One promising approach is the integration of hybrid solar panels into urban infrastructures. Hybrid solar panels, which combine photovoltaic (PV) vibration technologies, offer a unique opportunity to harness solar energy more efficiently. This dual functionality makes hybrid solar panels a versatile and efficient renewable energy source suitable for densely populated urban areas. Integrating renewable energy with green infrastructure fosters urban economic development by decreasing carbon emissions and enhancing the overall quality of life (Harahap et al. 2024). Hybrid systems integrating solar PV and renewable sources, like wind, can significantly enhance urban energy management. For instance, rooftop solar panels combined with wind turbines can provide a reliable energy supply, with excess energy stored for later use (Hassain et al. 2024). Hybrid solar wind systems have shown promise in urban energy generation, with forecasting methodologies achieving over 90% accuracy in predicting energy production (Javaid et al. 2024). This integration can alleviate pressure on power grids and enhance energy management. The use of vertical façades for solar energy generation in high-rise buildings can optimize energy production in densely populated areas. Research indicates that adjacent buildings significantly influence solar exposure, necessitating careful design considerations (Rababah et al. 2023). A techno-economic analysis of hybrid energy systems reveals that a significant portion of urban energy needs can be met through renewable sources, reducing reliance on fossil fuels and minimizing carbon emissions (Tewary, 2023). Balancing modern energy solutions with urban authenticity is crucial. Sustainable technologies must harmonize with historical and cultural identities to maintain the unique character of cities (Nursanty et al. 2024). Effective urban planning, supported by innovative policies, is vital for transitioning to sustainable energy systems, promoting efficient resource consumption and circular economy strategies (Amado & Poggi, 2022).

The concept of smart cities is examined as a crucial element in optimizing solar power integration within urban environments. By utilizing data analytics, Internet of Things (IoT) devices, and artificial intelligence, smart city initiatives are identified as transformative solutions for monitoring, controlling, and maintaining urban solar infrastructure (Bibri and Krogstie 2020). In pavement engineering, the application of